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To Mr. R. Wilson
Director
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RISK ASSESSMENT OF VDU ELECTRIC AND MAGNETIC FIELD EXPOSURES

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Electric and Magnetic field exposures produced by video display units are assessed in terms of existing occupational exposure standards and guidelines, general population exposures produced by the environmental background, and current knowledge of the biological effects of weak fields.

1. INTRODUCTION

This is the sixth and last of a series of reports prepared for Ontario Hydro Project HAVDU by the Research Division. In previous reports/1-5/, the electric and magnetic fields produced by video display units (VDUs) in the frequency range from DC to 1 MHz were measured and operator exposures to these fields were analyzed. In this report the present status of risk assessment as it relates to these electric and magnetic field exposures is briefly reviewed.

2. RISK ASSESSMENT

It is evident that if a person is exposed to an electric or magnetic field and the field level is continuously increased without limit, then at some point adverse physiological effects will become apparent. The fields producing these effects may be termed "strong" fields, and are obviously hazardous.

Most countries have radiation protection (or exposure) standards or guidelines that are designed to protect people from potentially hazardous exposures. Usually a substantial safety factor is built in.

job	file	date	report no.
740616-220-900	817.22	March 29, 1985	85-85-K

At the other end of the range there is assumed to be a threshold below which no biological effects of any kind can be observed. This threshold is constantly being reduced as diagnostic techniques become more and more sensitive.

In between is a broad area where biological effects are known or suspected but hazards are either non-existent or so obscure that research has not been able to reveal them. This is the area of "weak" field research. The lower limit of this area, the biological effects threshold, is now encroaching on the environmental exposure levels that are experienced on a daily basis by the general population. As a result, there is a large and growing international effort to determine if there are risks associated with electric and magnetic field exposures in the weak-field region.

The exposures received by VDU operators may, if defined in terms of recognized biological exposure parameters, be evaluated in terms of these occupational exposure standards and guidelines, environmental exposures, and weak-field studies. It should be noted that uncorrected electric-field emission measurements, commonly reported in the VDU literature, are usually not interchangeable with the required exposure parameters.

3. EXPOSURE STANDARDS AND GUIDELINES

Occupational Exposure standards and guidelines are regularly updated and represent the current consensus among national and international agencies concerning the possible human health risks associated with exposure to electromagnetic fields and waves. No scientific study known to the writer has identified a health risk from VDUs on the basis of these documents, some of which are briefly reviewed below.

Reference is made to the following North American and European Documents. One Eastern Block standard is included, since it is reported to be the most restrictive standard in effect in any country.

(A) Exposure Criteria for Potentially Harmful Agents and Substances in Work Places. Ontario Ministry of Labour, 1981.

(B) Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz to 100 GHz. American National Standard ANSI C95.1-1982.

(C) Interim Guidelines on Limits of Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 100 kHz to 300 GHz. International Non-Ionizing Radiation Committee of the International Radiation Protection Association (IRPA), 1984/6/.

(D) TLVs Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes for 1983-1984. American Conference of Governmental Industrial Hygienists (ACGIH), 1983.

(E) Proposals for the Health Protection of Workers and Members of the Public Against the Dangers of Extra Low Frequency, Radiofrequency, and Microwave Radiations: A Consultative Document, UK National Radiological Protection Board (NRPB), 1982.

(F) Modified Version of Standard Method for Determining Field Intensity and Electromagnetic-Wave Irradiation in the Rf and Uhf Range for Health Purposes: Prophylactic Examinations of Operating Personnel and Other Individuals Exposed to such Irradiation, (Modification of Czechoslovac Regulation HE-344, 1965).

Documents A, B, and C do not apply in the frequency range of interest for VDUs (<100 kHz) and so may be excluded from further consideration. However, document B forms a basis for documents D and E. It is therefore worth reading.

Document D is an adaptation of document B for adult occupational exposures. It covers an extended frequency range from 10 kHz to 300 GHz. It is stated that the exposure limits are "selected to limit the average whole body specific absorption rate (SAR) to 0.4 W/kg in any six minute (0.1 h) period for 3 MHz to 300 GHz". The rationale for extending frequency limits to 10 kHz is the prevention of radio-frequency burn and shock hazards from low-frequency transmitters, since the human body absorbs little energy at low frequencies. Whole body exposures in the frequency range from 10 kHz to 3 MHz are limited to a radiated power density of 100 mW/cm^2 averaged over any 0.1 h period. The corresponding electric and magnetic field limits, calculated from radiated plane-wave relationships, are for continuous 8 h day exposure E^2 = 377 000 V^2/m^2 (E = 614 V/m), and H^2 = 2.65 A^2/m^2 (H = 1.63 A/m). However, exposure to devices having a radiated output power of 7 W or less is unrestricted up to an electric field maximum of 100 kV/m, if the SAR is less than 0.4 W/kg averaged over the whole body and the spatial peak SAR is less than 8.0 W/kg averaged over any 1.0 g of tissue. This exclusion would apply to VDUs. It is based on the premise that such low-power devices cannot pose energy absorption or burn and shock hazards.

Document E is similar to D except that the low frequency limit is further reduced to 3 kHz. The only limitation on devices having a radiated output power of less than 7 W is that they

should be designed and used so that they are unable to deliver more than 4 W/kg to the eyes for prolonged periods.

Document F, the Czechoslovak standard, places no limits on human exposure to magnetic fields below 300 MHz, or to electric fields below 30 kHz. The electric field boundary excludes the fundamental frequency of the electric field produced by the VDU circuits operating between 15 and 22 kHz, but includes the higher harmonics. Human exposure measurements would have to be adjusted accordingly. Limits for whole body electric field exposure in the frequency range from 30 kHz to 30 MHz for an 8 h working day are expressed as a product of average field strength in V/m and time in hours. A maximum value of 400 V·h/m is permitted; corresponding to 50 V/m for 8 h or 4000 V/m averaged over a 0.1 h period. No supporting material was supplied with this document. Therefore, the rationale for the limits and their applicability to low radiated power devices are presently unknown.

No standards presently exist in North America for exposure to electric or magnetic fields below 3 kHz. A limit of 1000 V/m has been suggested for continuous exposure to the electric fields from HVAC power lines/7/. In a similar study for HVDC power lines, no practical limit on DC electric or magnetic fields was found to be necessary/8/.

It is readily established that any exposure received by VDU operators or other office personnel as a result of working in close proximity to a VDU is completely safe according to the North American and Western European Standards and Guidelines/9,10,11/.

Exposures theoretically achievable in close proximity to a few VDUs may be technically in violation of the Czechoslovac standard. However, this does not imply that the exposures are therefore unsafe. The Czechoslovac standard differs from Western standards in that it defines exposure in terms of a simple field measurement instead of the effects on the human body. This approximation is acceptable if the standard is applied only to exposures in uniform or nearly uniform fields. When applied literally to localized short-range electric fields such as those that exist close to VDUs, it can lead to absurd results. It is unlikely that the standard was intended to be applied in this way.

When field measurements are converted to biological exposure parameters for comparison, the Czechoslovac standard places no practical limitation on VDU exposures.

4. ENVIRONMENTAL BACKGROUND

The general population, particularly in developed urban areas, is exposed on a daily basis to low-level electric and magnetic fields in the frequency range from DC to 1 MHz from many sources. Natural fields include the earth's geomagnetic field and the highly variable electric field produced at the earth's surface by atmospheric charge separation. Man-made fields include those produced by power lines and communications systems (see Table 1) and also those produced by most electrical and electronic devices. Devices that produce significant electric or magnetic fields in this frequency range include household wiring, the telephone, the electric blanket, waterbeds, electric typewriters, hand calculators, photoflash attachments, motor driven appliances, home stereo systems, TV sets, fluorescent lights, and video display units.

TABLE 1

RADIO FREQUENCY BANDS/12/

Frequency	Wavelength	Band Designation	Typical Uses
0.3 - 3.0 MHz	10^3-10^2 m	Medium Frequency (MHF)	Communications, radio navigation, marine radiophone, amateur, industrial RF equipment, AM broadcast
30-300 kHz	10-1 km	Low Frequency (LF)	Radio navigation marine communication, long-range communications
3-30 kHz	100-10 km	Very Low Frequency (VLF)	Very long range communications, audio-frequencies navigation
0.3-3 kHz	10^3-10^2 km	Voice Frequency (VF)	Voice, audio-frequencies
30-300 Hz	10^4-10^3 km	Extremely Low Frequency (ELF)	Power lines, audio-frequencies, submarine communications
0-30 Hz	$\approx 10^4$ km	Sub ELF	Direct-current power lines

One method of establishing relative risk for VDU operators is to compare their exposure to this environmental background. Enough information is available for natural fields/13/, 60 Hz fields/14,15/ and AM broadcast fields/16/ to allow such a comparison at least on a qualitative basis. Probabilistic field-strength curves are shown in Figures 1, 2 and 3 for VDUs and these background sources. The VDU data are expressed in terms of "worst-case" equivalent environmental fields for a position 30 cm from the display screen.

These curves show that Ontario Hydro VDU operator exposures to electric and magnetic fields are within the range of environmental background exposures received daily by the general population without apparent ill effect. Under normal office conditions, other personnel will receive exposures that are not environmentally significant.

5. WEAK FIELDS

To proceed further with risk assessment, one must turn to current research into the biological effects of weak fields. The literature in this area is very extensive, often obscure, frequently controversional and occasionally unreliable. It requires expert evaluation that is beyond the scope and resources of the present study. Fortunately, it has recently been pretty thoroughly reviewed by health professionals and reference may be made to their findings. The following is a brief summary.

It is now accepted that some low-frequency electric and magnetic fields within the ranges permitted by existing guidelines can produce measurable biological effects in the laboratory. In most cases neither the mechanisms nor the dosimetry are understood so that extrapolation to humans in the real world is not possible. It has not been confirmed that such biological effects can be observed in the human population nor has it been established that such effects, if found, would be detrimental to human health. However, because of this uncertainty, it is suggested that some exposure levels be further limited as a cautionary measure.

In the ELF (extremely low frequency) range/7/ a general population limit of 1000 V/m, measured at the edge of a 60 Hz transmission-line right-of-way, is proposed. In the radio frequency ranges/17,18/, a reduction of the risk-threshold specific absorption rate (SAR) from 4 W/kg to 1 W/kg has been suggested. Existing North American standards use a safety factor of 10 for whole-body absorption so this change, if accepted, would change the relevant data in Section 3 from 0.4 W/kg to 0.1 W/kg.

These proposed new guidelines would have no impact on VDU exposures. Professional reviews that have recently been written with specific reference to VDU exposures, and which therefore take into account research pertaining to the particular field waveforms produced by VDUs, are consistent with this negative risk assessment. The following quotations exemplify the findings.

"The author has found no valid evidence that would indicate any health hazard associated with NEMF (nonionizing electromagnetic field) exposures of persons operating VDTs"/11/.

"There is no scientific or clinical evidence of deleterious effects resulting from exposure to radiation emissions from video display terminals"/19/.

"In our opinion, there exist today no indications that VDU work should be considered a risk factor for pregnant women; neither as to spontaneous abortions, nor to congenital defects"/20/.

6. CONCLUSIONS

The risks associated with exposure to the electric and magnetic fields produced by VDUs may be assessed with respect to occupational exposure standards, the environmental background, or the results of research into the biological effects of weak fields.

Any achievable VDU exposure is safe according to occupational exposure standards or guidelines in effect in western block countries. Eastern block standards may be technically exceeded under unusual circumstances but a risk is not implied. General exposure standards to be applied to VDUs or similar devices need to be defined in terms of biological exposure parameters rather than field strength.

The exposures received by operators or other office personnel at normal VDU working distances in Ontario Hydro work stations are within the range of environmental background exposures received daily by the general population without apparent ill effects.

Weak-field studies have evidently caused a substantial revision in thinking about the biological activity of low-level electric

and magnetic fields. However, in spite of extensive research, such studies cannot at present prove or disprove the safety of VDU or any other common environmental exposures. The best available risk assessment is therefore the informed consensus of health professionals. According to this consensus, there is no valid evidence that exposure to the electric and magnetic fields produced by video display units is injurious to human health.

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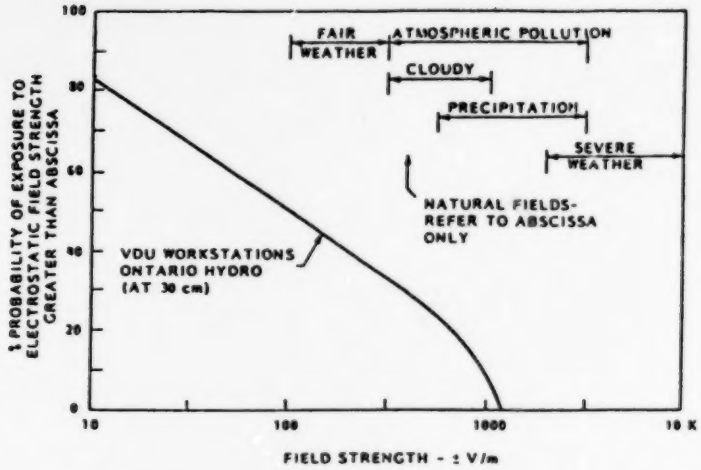
% PROBABILITY OF EXPOSURE TO ELECTROSTATIC FIELD STRENGTH GREATER THAN ABSCISSA
FAIR WEATHER
ATMOSPHERIC POLLUTION
CLOUDY
PRECIPITATION
SEVERE WEATHER
NATURAL FIELDS- REFER TO ABSCISSA ONLY
VDU WORKSTATIONS ONTARIO HYDRO (AT 30 cm)
FIELD STRENGTH - ± V/m

FIGURE 1. COMPARISON OF ENVIRONMENTAL ELECTROSTATIC FIELDS

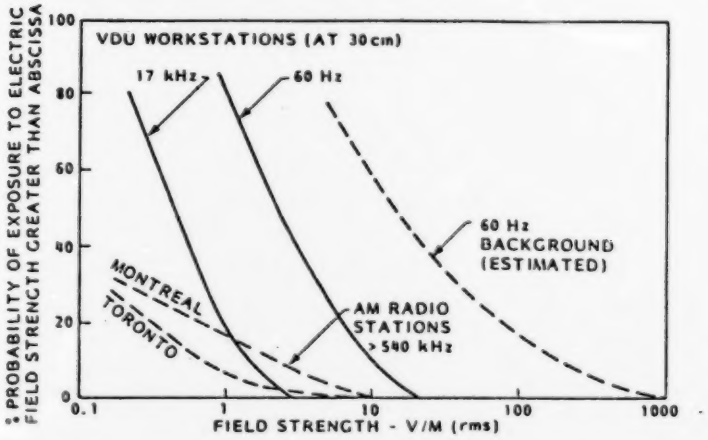

FIGURE 2. COMPARISON OF ENVIRONMENTAL ELECTRIC FIELDS

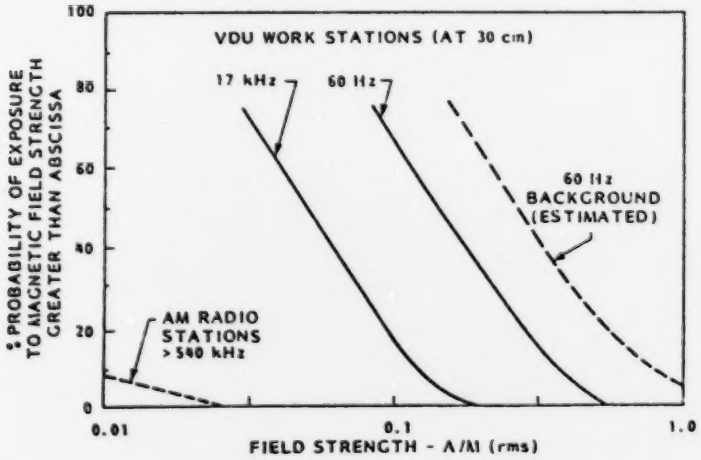
% PROBABILITY OF EXPOSURE TO MAGNETIC FIELD STRENGTH GREATER THAN ABSCISSA
VDU WORK STATIONS (AT 30 cm)
17 kHz
60 Hz
60 Hz BACKGROUND (ESTIMATED)
AM RADIO STATIONS >540 kHz
FIELD STRENGTH - A/M (rms)

FIGURE 3. COMPARISON OF ENVIRONMENTAL MAGNETIC FIELDS

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